BENEFITS OF HIGH AERODYNAMIC EFFICIENCY TO ORBITAL TRANSFER VEHICLES*

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An analysis of the benefits and costs of high aerodynamic efficiency on aeroassisted orbital transfer vehicles (AOTV) is presented. These results show that a high lift-to-drag (L/D) AOTV can achieve significant velocity savings relative to low L/D aerobraked OTV's when traveling round trip between low Earth orbits (LEO) and alternate orbits as high as geosynchronous Earth orbit (GEO). Trajectory analysis is used to show the impact of thermal protection system technology and the importance of lift loading coefficient on vehicle performance. The possible improvements in AOTV subsystem technologies are assessed and their impact on vehicle inert weight and performance noted. Finally, the performance of high L/D AOTV concepts is compared with the performances of low L/D aeroassisted and all-propulsive OTV concepts to assess the benefits of aerodynamic efficiency on this class of vehicle.

*Work supported by U.S. Air Force Wright Aeronautical Laboratories and Boeing Aerospace Company.

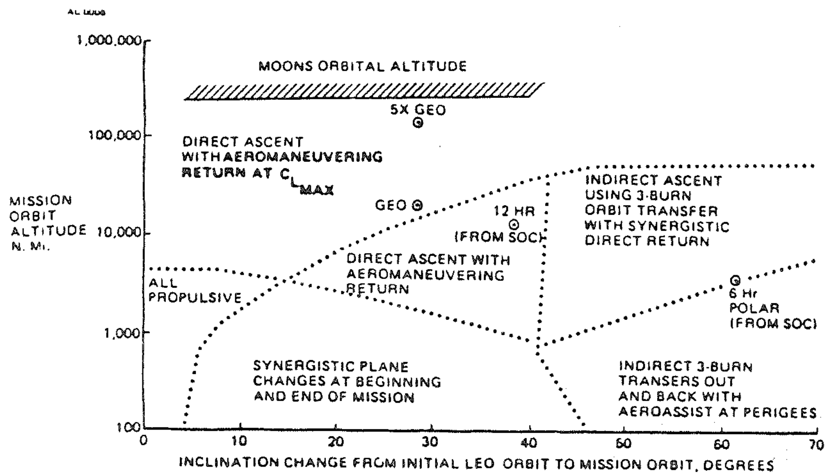

Figure 1. Synthesis of Optimum AOTV Mission Scenarios

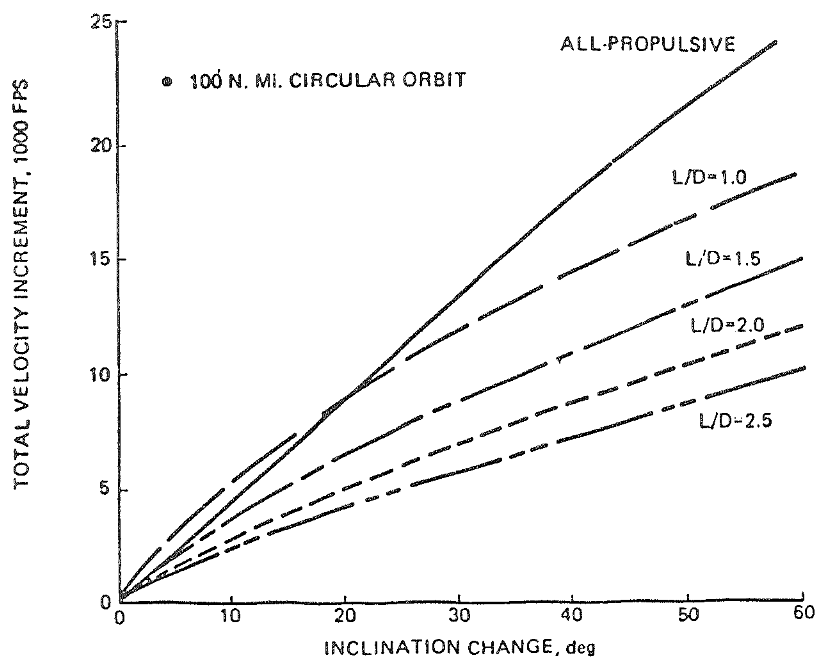

Figure 2. Effect of Vehicle L/D on Plane-Change Capability

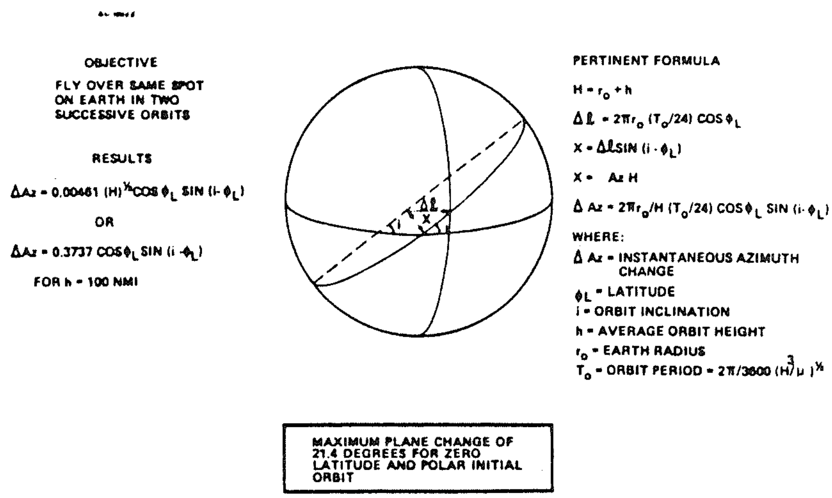

Figure 3. Synergistic Plane-Change Maneuver for Ground-Based AOTV

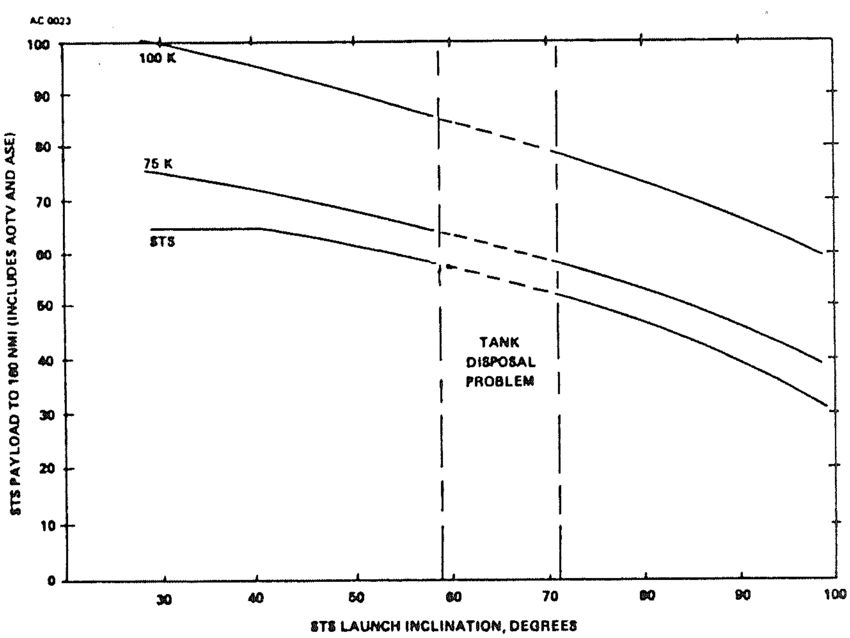

Figure 4. Ground-Based AOTV Insertion Weight

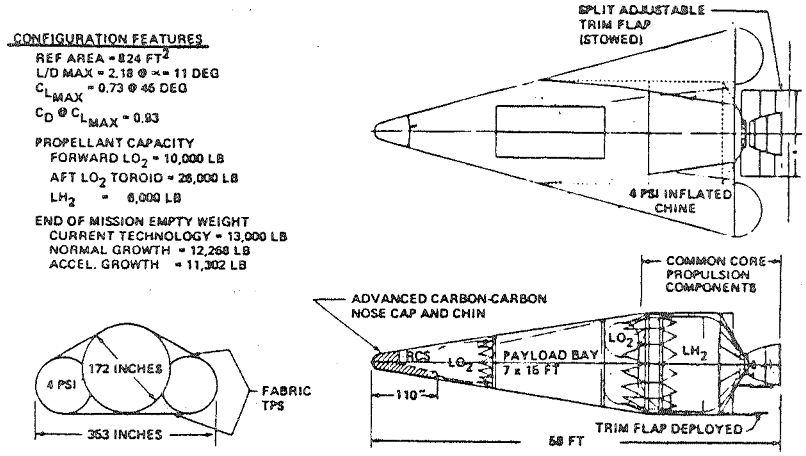

Figure 5. Ground-Based AOTV Configuration

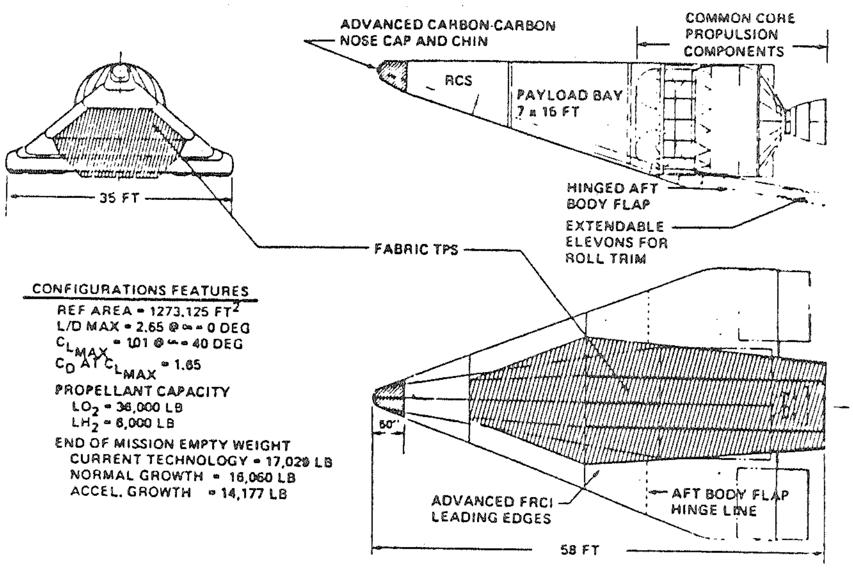

Figure 6. Space-Based AOTV Configuration

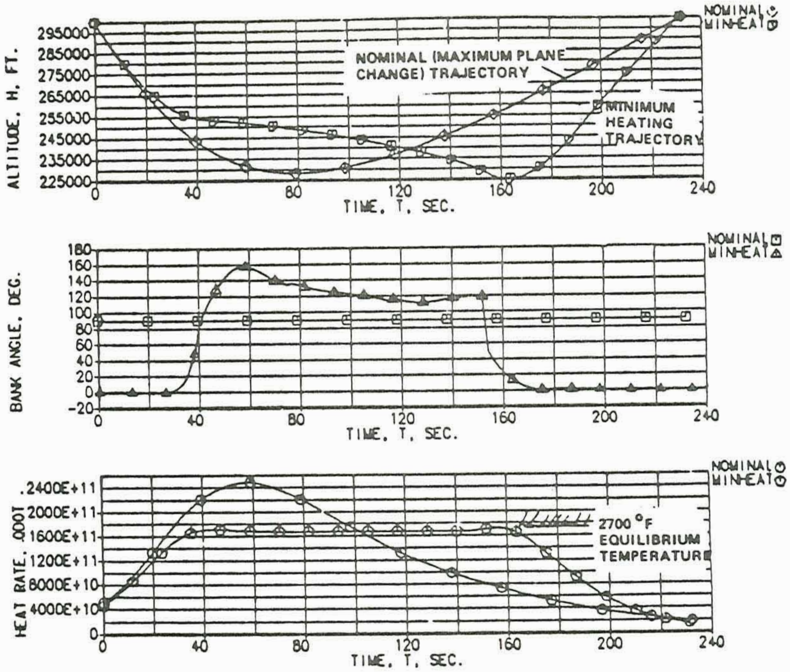

Figure 7. Inflatable Chine AOTV 5xGEO Reentry Trajectory Comparison

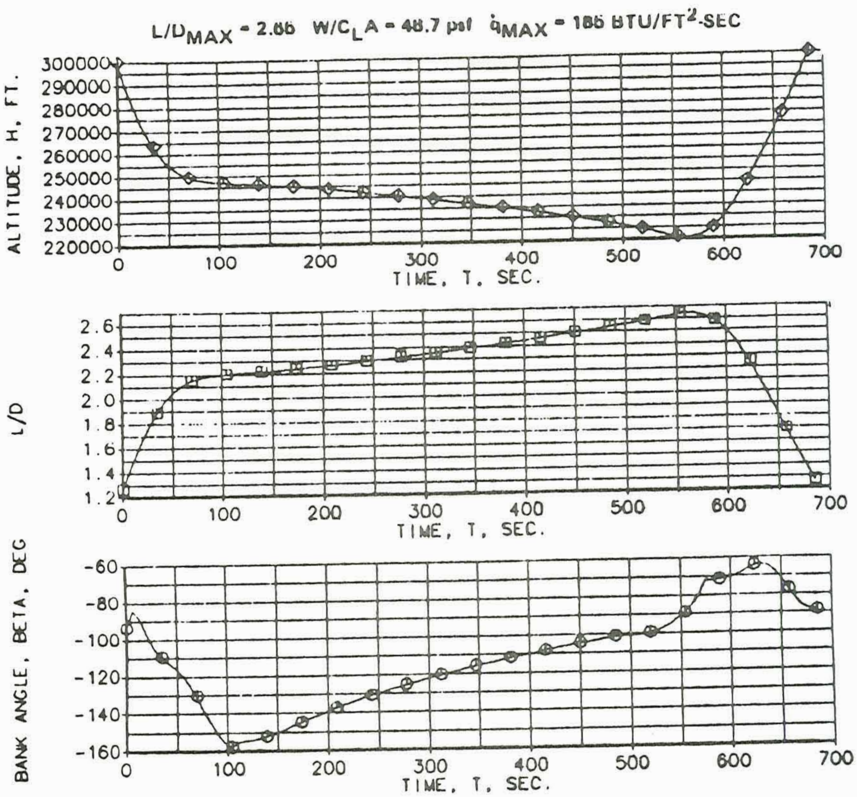

Figure 8. Space-Based High L/D AOTV Optimized GEO Reentry Trajectory

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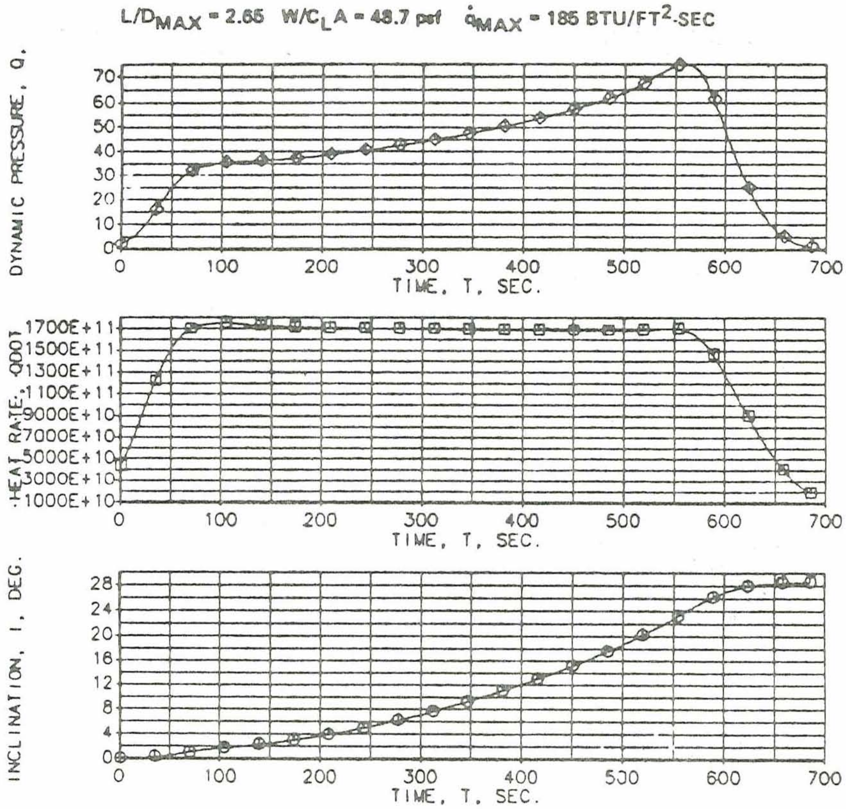

Figure 8. Space-Based High L/D AOTV Optimized GEO Reentry Trajectory (Cont'd)

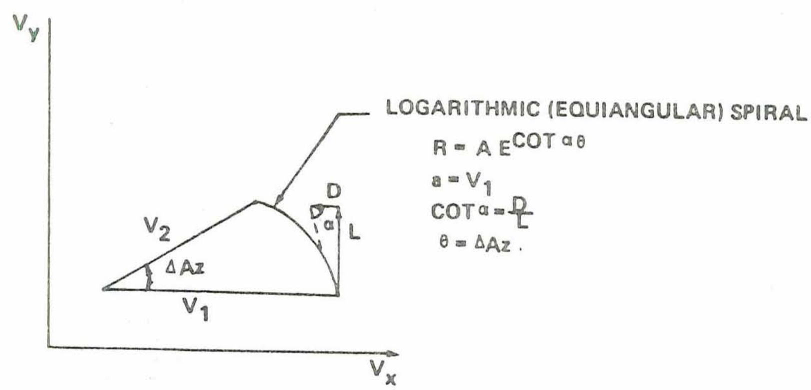

Figure 9. Aeromaneuver in Velocity Space

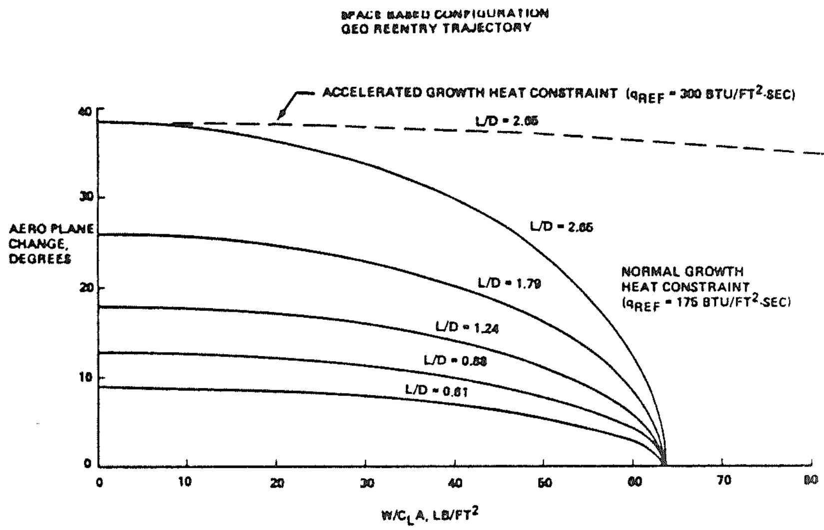

Figure 10. Impact of Heating Constraints on Aero Plane-Change Capability

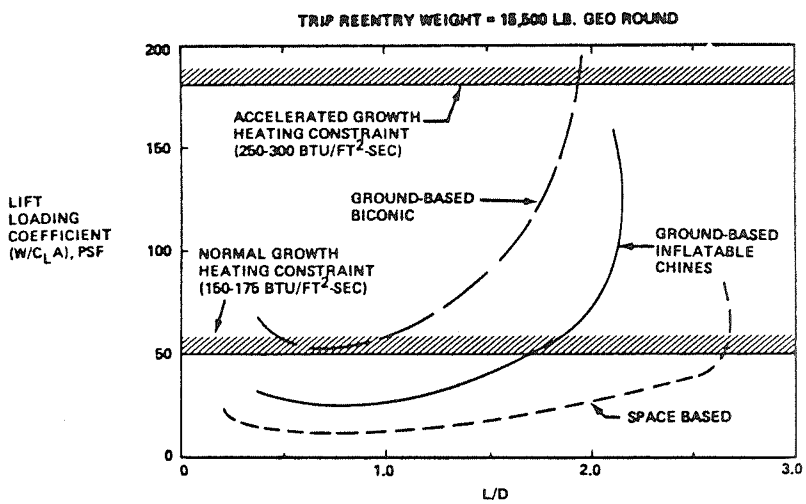

Figure 11. Impact of Heating Constraints on Reentry L/D Ratio

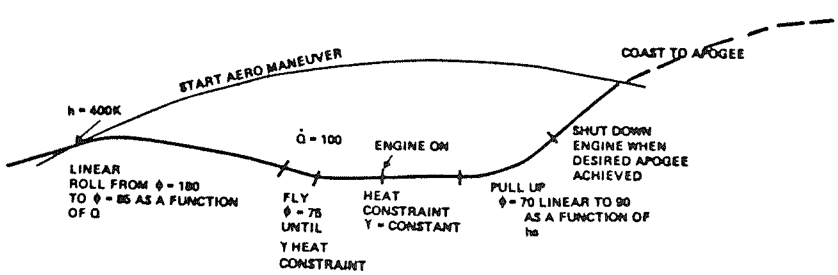

Figure 12. Synergistic Atmospheric Phase

SUCCESSIVE OVERFLIGHTS, INCLINATION = 57 DEG.
INFLATABLE CHINE AT 15 DEG ANGLE OF ATTACK

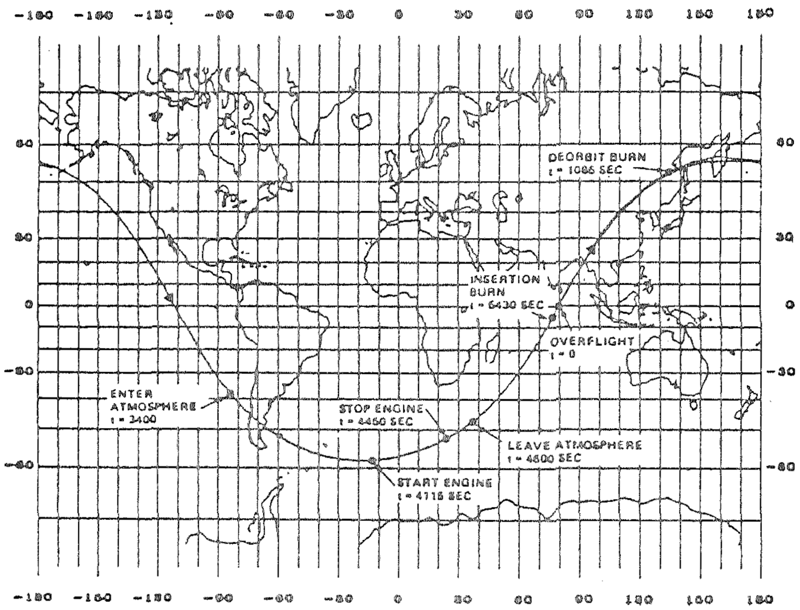

Figure 13. Ground-Based Sortie Mission

INCL = 57 DEG, ΔAz = 17.8 DEG, α = 15 DEG, L/D = 2.08, $\dot{q}_{MAX}$ = 150 BTU/FT^2-SEC, W/C$_L$A = 242 PSF

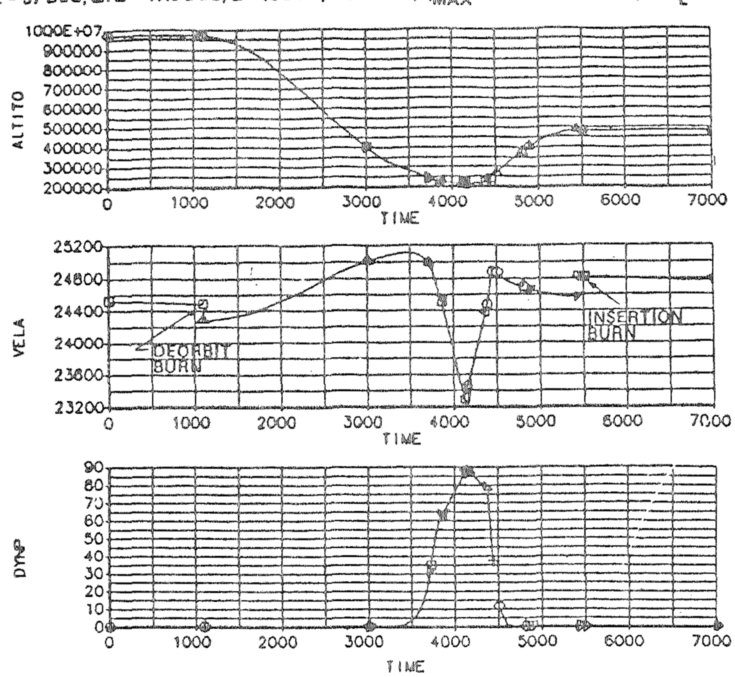

Figure 14. Ground-Based Sortie Mission

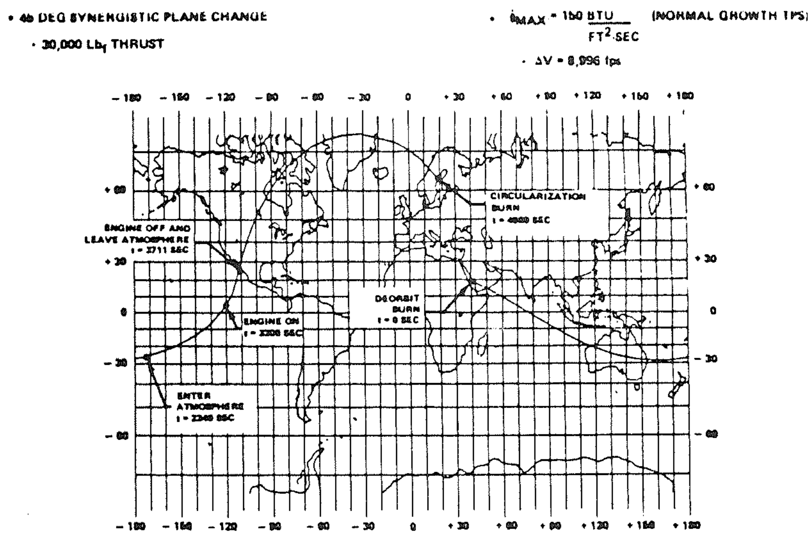

Figure 15. Space-Based Sortie Mission

• CONSTANT ANGLE OF ATTACK FOR L/D MAX

• 150 $\frac{\text{BTU}}{\text{FT}^2\text{-SEC}}$ MAXIMUM HEATING RATE

• 45 DEGREE PLANE CHANGE USING SPACE-BASED AOTV

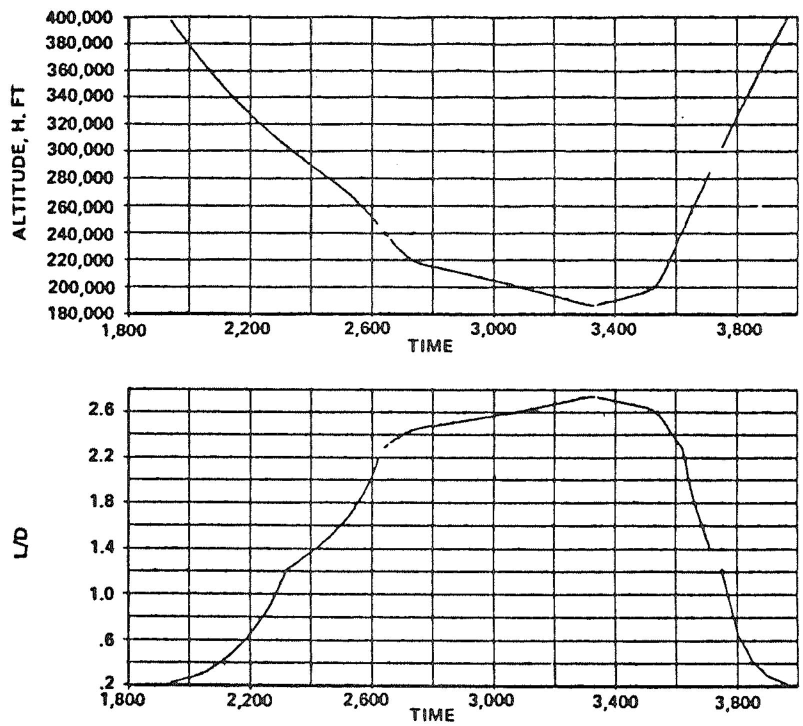

Figure 16. Variation in L/D_{Max} Over Synergistic Plane-Change Trajectory

Δ INC = 45 DEG, L/D_{MAX} = 2.65, $\left(\frac{W}{C_L A}\right)$ INITIAL = 205 psf

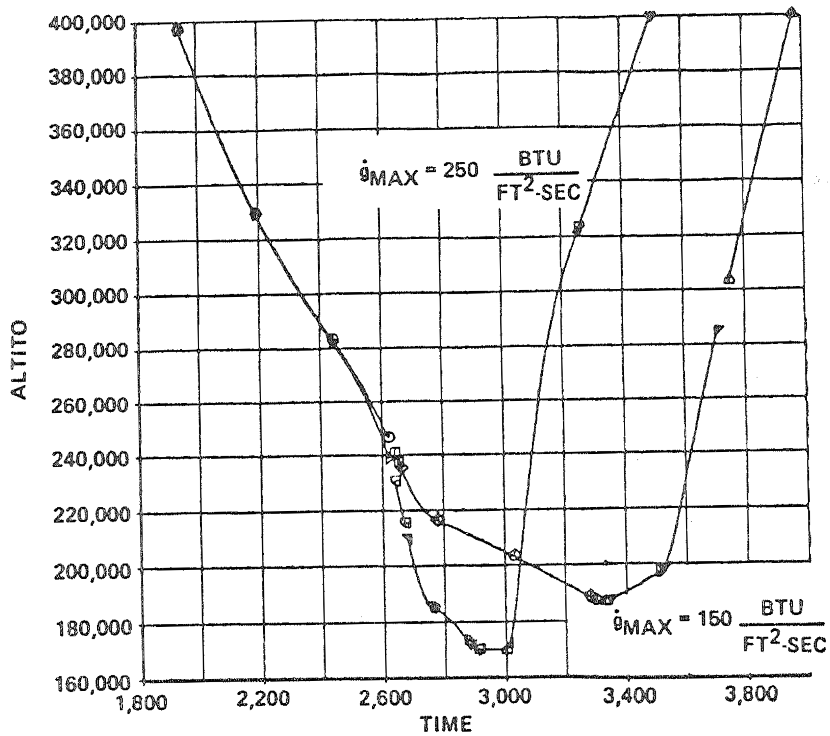

Figure 17. Space-Based Sortie Mission

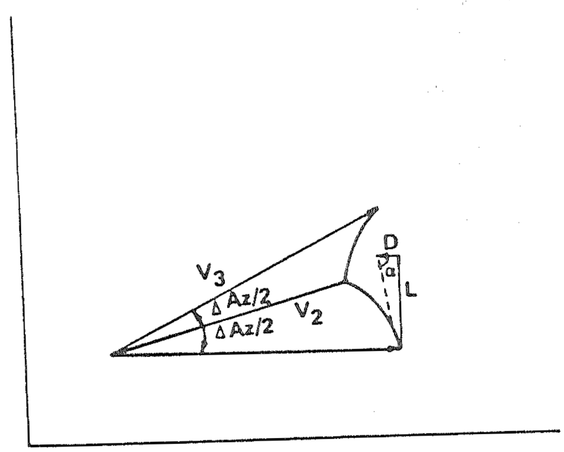

Figure 18. Synergistic Maneuver in Velocity Space

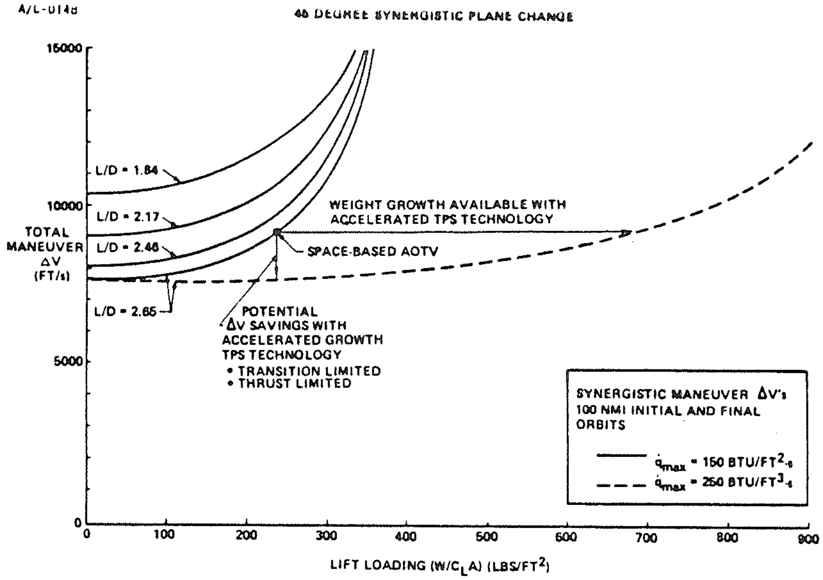

Figure 19. Impact of TPS Technology on Space-Based AOTV

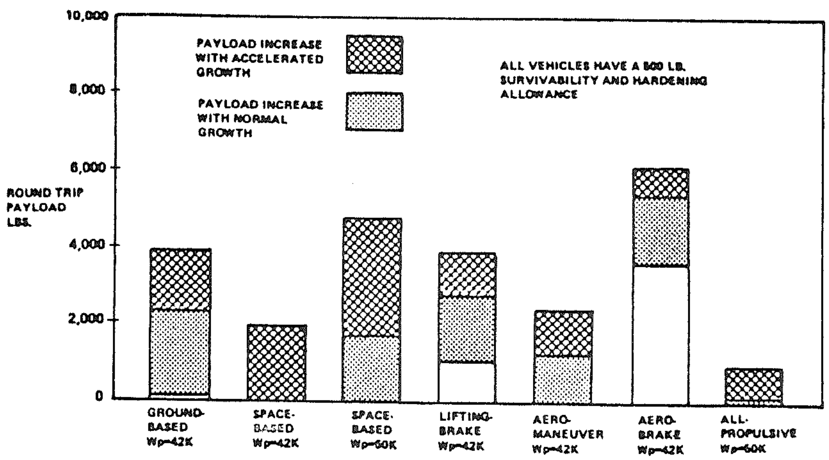

Figure 20. Round Trip GEO Mission Performance Comparison

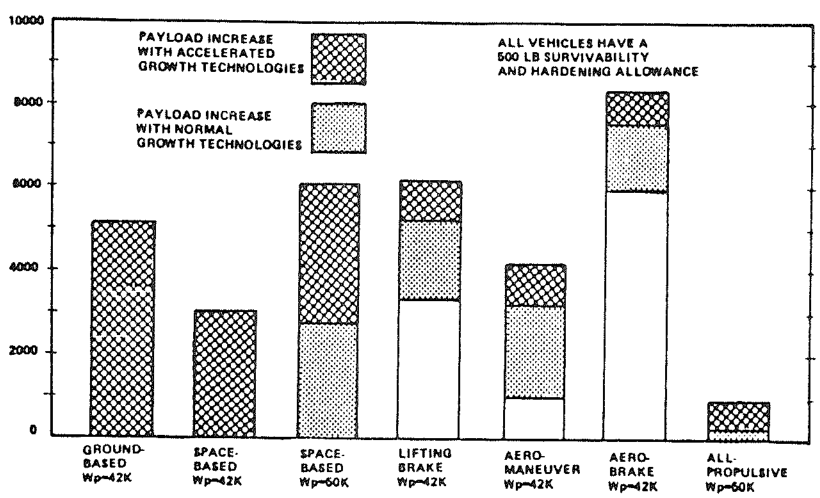

Figure 21. Round Trip 5xGEO (Polar) Mission Performance Comparison

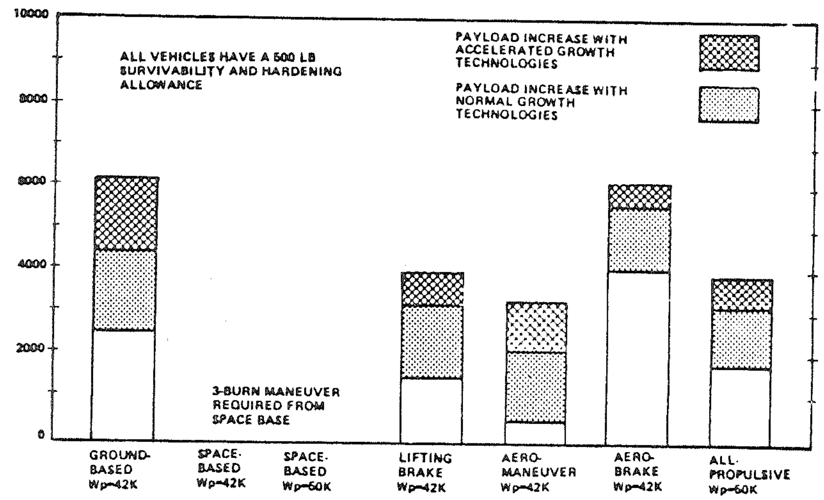

Figure 22. Round Trip 6-Hour Polar Orbit Mission Comparison

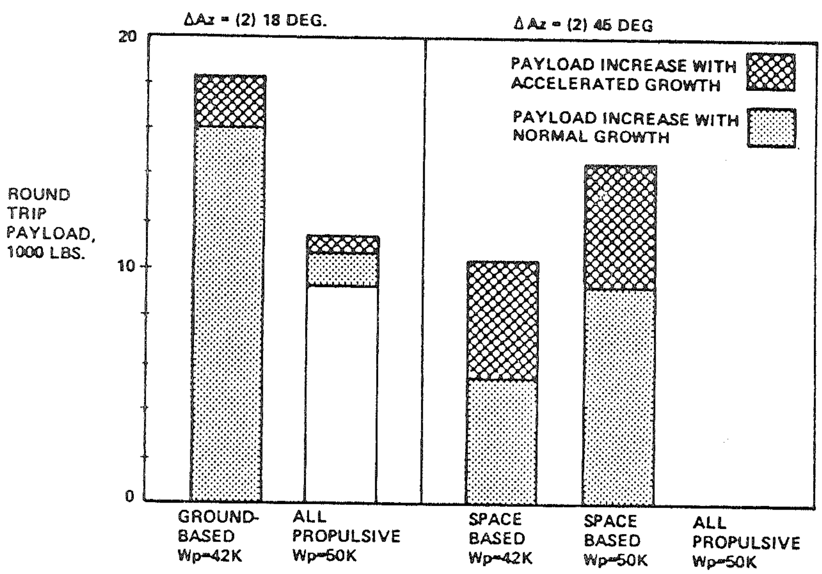

Figure 23. Synergistic Plane-Change Mission Performance Comparison